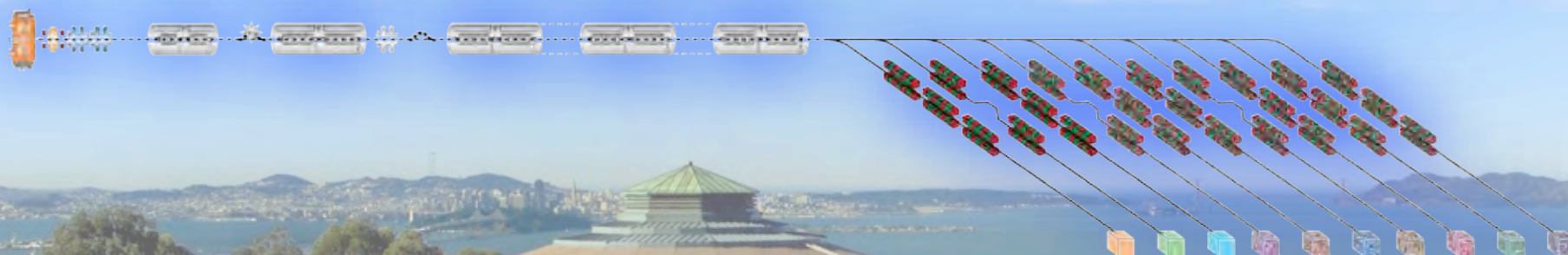
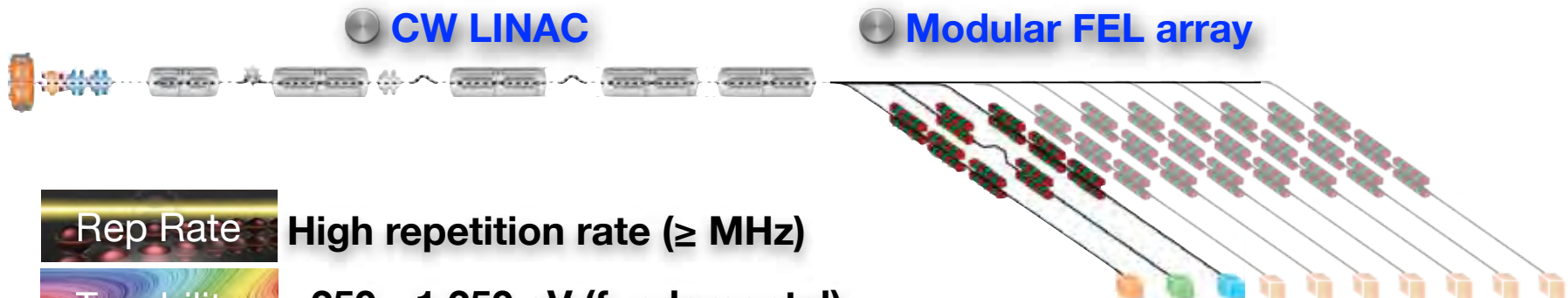


a next generation light source

Status Update

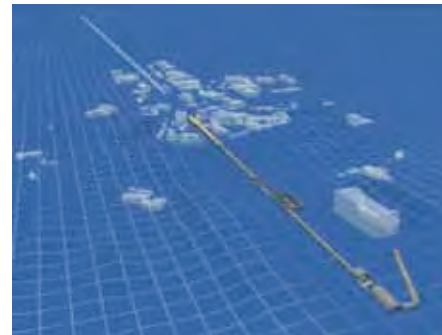


a next generation light source



Rep Rate	High repetition rate (\geq MHz)
Tunability	~250 - 1,250 eV (fundamental)
Coherence	Seeded operation

X-ray Laser Capabilities



Storage Ring Utility & Friendliness

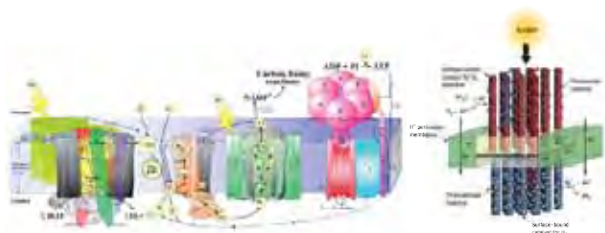


NGLS will have:

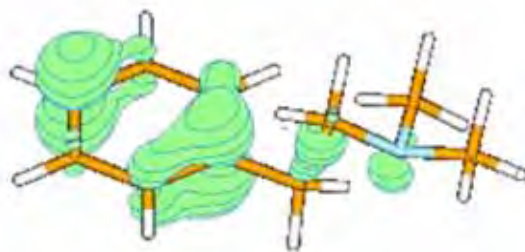
- More photons per unit bandwidth
- More photons per second
- Shorter pulses
- With a controlled trade-off between pulse length and energy resolution

broad range of energy science uniquely enabled by NGLS

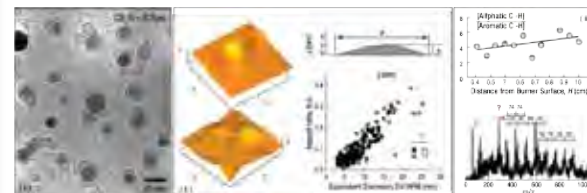
Natural and Artificial Photosynthesis



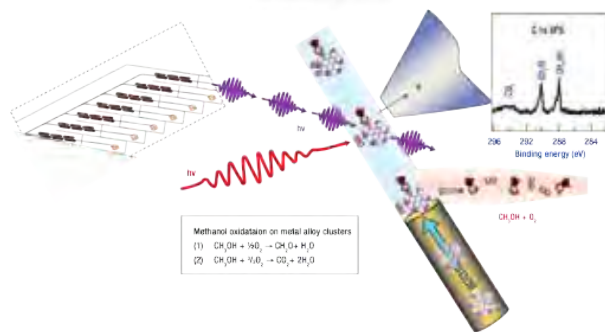
Fundamental Charge Dynamics



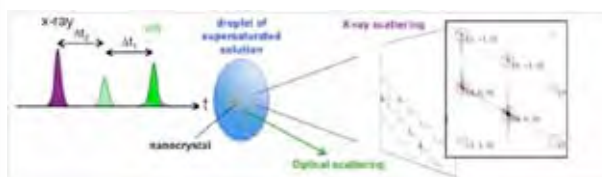
Advanced Combustion Science



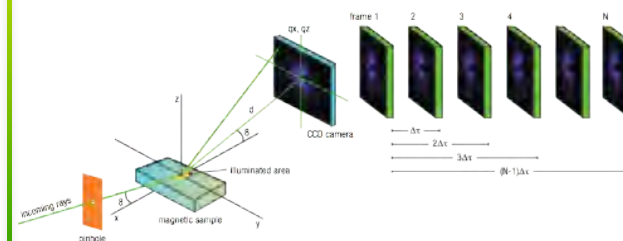
Catalysis



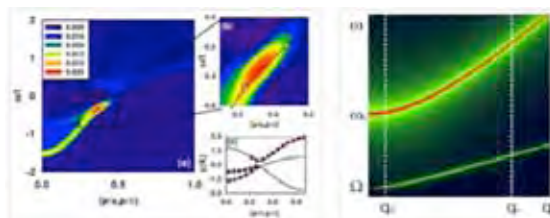
Nanoscale Materials Nucleation



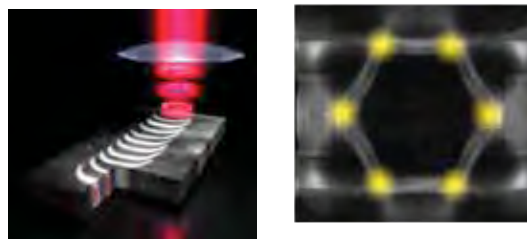
Dynamic Nanoscale Heterogeneity



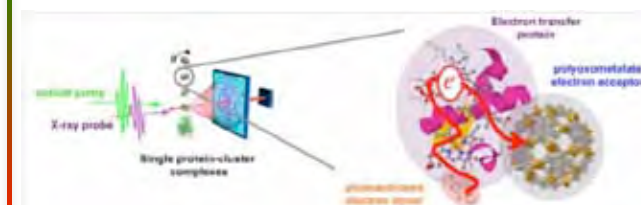
Quantum Materials



Nanoscale Spin and Magnetization



Bioimaging: Structure-to-Function



time to do experiments - photosynthesis



Required	10^{17}	photons
Damage Limit	10^8	ph/pulse
Max Rep. Rate	10^5	Hz

Time to do experiment:

Photons Required / (Photons/Pulse x Rep. Rate)

	Source (<i>intrinsic</i>)		Time to do experiment	Time resolution	
	Max. ph/pulse	Max. Rep. rate [Hz]			
Storage Ring	10^5	5×10^8	$10^{17}/10^5/10^5$	100 days	100 ps
Pulsed FEL	10^{10}	10^2	$10^{17}/10^8/10^2$	100 days	~fs
NGLS	10^9	10^6	$10^{17}/10^8/10^5$	3 hours	~fs

Rep Rate

Tunability

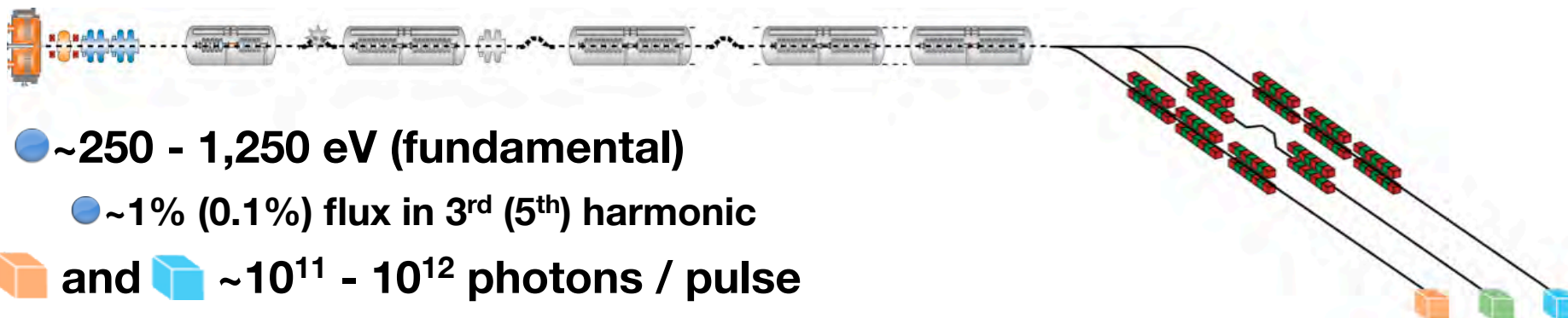


U.S. DEPARTMENT OF
ENERGY

Office of
Science



NGLS in 2022



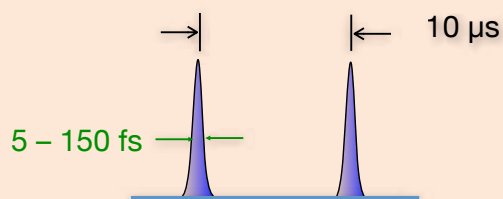
● ~250 - 1,250 eV (fundamental)

● ~1% (0.1%) flux in 3rd (5th) harmonic

■ and ■ ~10¹¹ - 10¹² photons / pulse

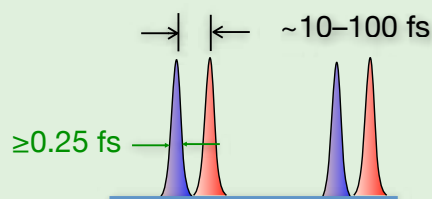
■ and ■ may both be self-seeded FELs

■ ~10⁸ - 10⁹ photons / pulse



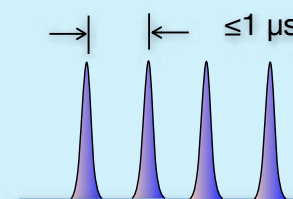
- Seeded
- ~Time-bandwidth limited
- $10^{-3} - 5 \times 10^{-5} \Delta\omega / \omega$

*Trade time / energy
resolution*



- Seeded
- Ultra-fast
- 250 as pulses

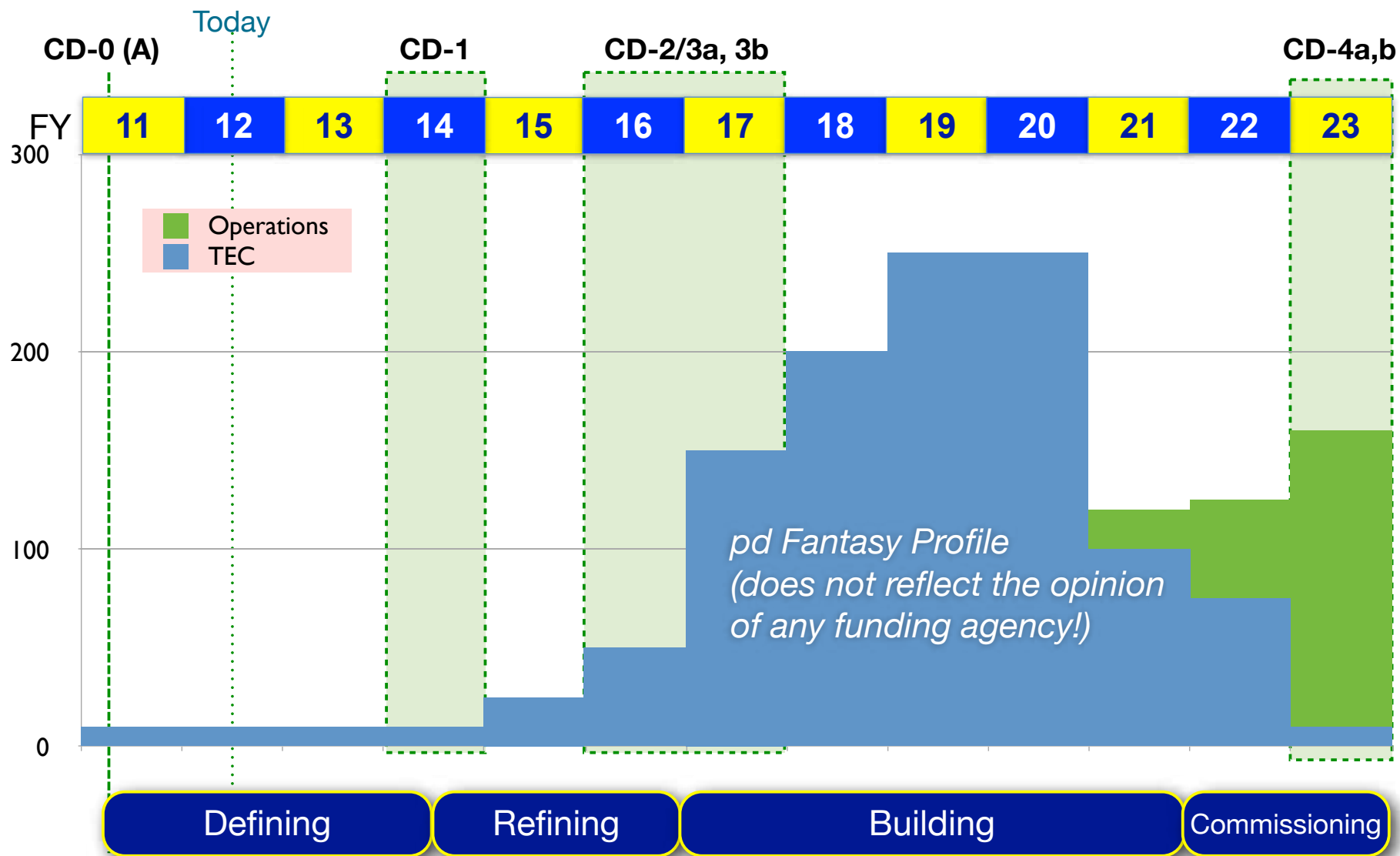
Two color



- (self-seeded) SASE
- Highest rate
- 10³ x XFEL, 10⁶ x LCLS

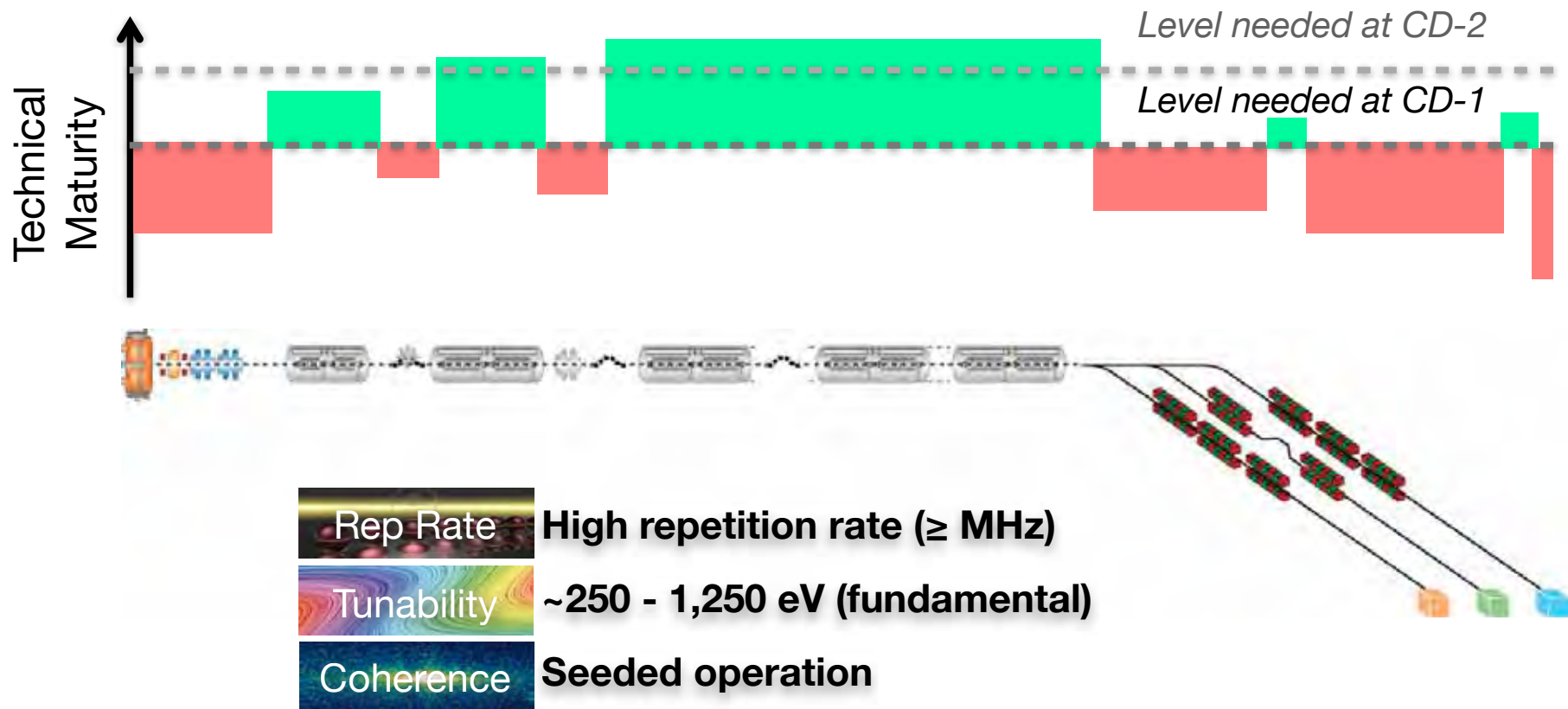
*Highest power
Limited only by gun rate*

assumptions - updated from the time of CD-0



areas addressed by R&D

- Bring all items up to needed technical maturity
- **Many technologies** (e.g. linac) sufficiently mature
- **R&D program** focuses on technology maturation (described below)

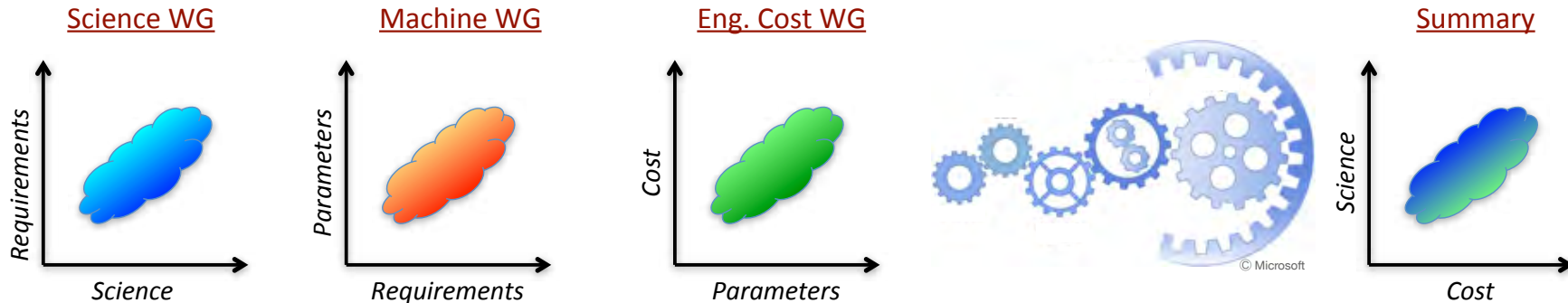


Technology Readiness Assessment

- Purpose: prioritize R&D needed to get to CD-1
- Walk through WBS at Level 3
- R&D to get to TRL ≥ 4 by CD-1
- Design needed to get to TRL ≥ 4 by CD-1

Proponent	WBS	Name	TRL	Dictionary	References and Comments
Filippetto	1.1.5	Drive Laser System	5	<p>The drive laser system provides photon pulses at a wavelength matched to the work-function of the photocathode material, with sufficient energy per pulse to emit the required number of electrons, and with the appropriate temporal and spatial shape to control beam dynamics of the emitted electrons. For CsTe photocathodes, operating laser systems exist at high repetition rate in burst mode, e.g. at FLASH. For alkali antimonides, lasers of required power are commercially available. What is needed are controls and filtering, and diagnostics, to provide spatial and temporal characteristics specific to NGLS needs, in a CW 1 MHz system. Transverse (position) and longitudinal (timing) feedback systems are also needed to achieve the pulse to pulse stability required. APEX will test these systems, which may be different depending on photocathode materials.</p>	<p>All the subsystems have been proven to work separately, and most of them have also been proven in the system an accelerator environment. Fiber laser (oscillator + amplifier) systems (ref.[1]) with the similar wavelength, energy per pulse and repetition rate are commercially available. The TRL also depends on energy per pulse needed, which in turn depends on the choice of cathode material.</p> <p>The challenge resides on interfacing the drive laser with the accelerator satisfying all the tight tolerances requested by user facility. Longitudinal pulse shaping of high rep. rate lasers has already been proven (ref. [2]), but further improvements will be required to get better results. Time and space stability tolerances require feedbacks on the system. The high repetition rate opens the door to high bandwidth feedbacks and can in principle make it very stable. Such systems are state of the art and could be implemented and proven already in the APEX laser.</p> <p>In conclusion, it can be said that all the subsystems are state of the art, but the new challenge of building a very stable laser of a future user facility, decreases the level of readiness down to 5.</p> <p>References [3] and [4] below describe similar high repetition rate laser systems, giving a sense of the level of complexity.</p> <p>[1] see for example: http://www.calmarlaser.com/products/fiber_laser/cazadero.php</p> <p>[2] I. Bazarov et. al., Phys. Rev. ST Accel. Beams 11, 040702 (2008)</p> <p>[3] Ingo Will, Horst I. Templin, Siegfried Schreiber, and Wolfgang Sandner, "Photoinjector drive laser of the FLASH FEL," Opt. Express 19, 23770-23781 (2011)</p> <p>[4] D.G. Ouzonov, I. Bazarov, B. Dunham and C. Sinclair, "The Laser System for the ERL Electron Source at Cornell University", Proceedings of PAC07, Albuquerque, New Mexico, USA.</p>

system trade studies



Natural and Artificial Photosynthesis	Fundamental Charge Dynamics	Advanced Combustion Science
Catalysis	Nanoscale Materials Nucleation	Dynamic Nanoscale Heterogeneity
Quantum Materials	Nanoscale Spin and Magnetization	Bioimaging: Structure-to-Function

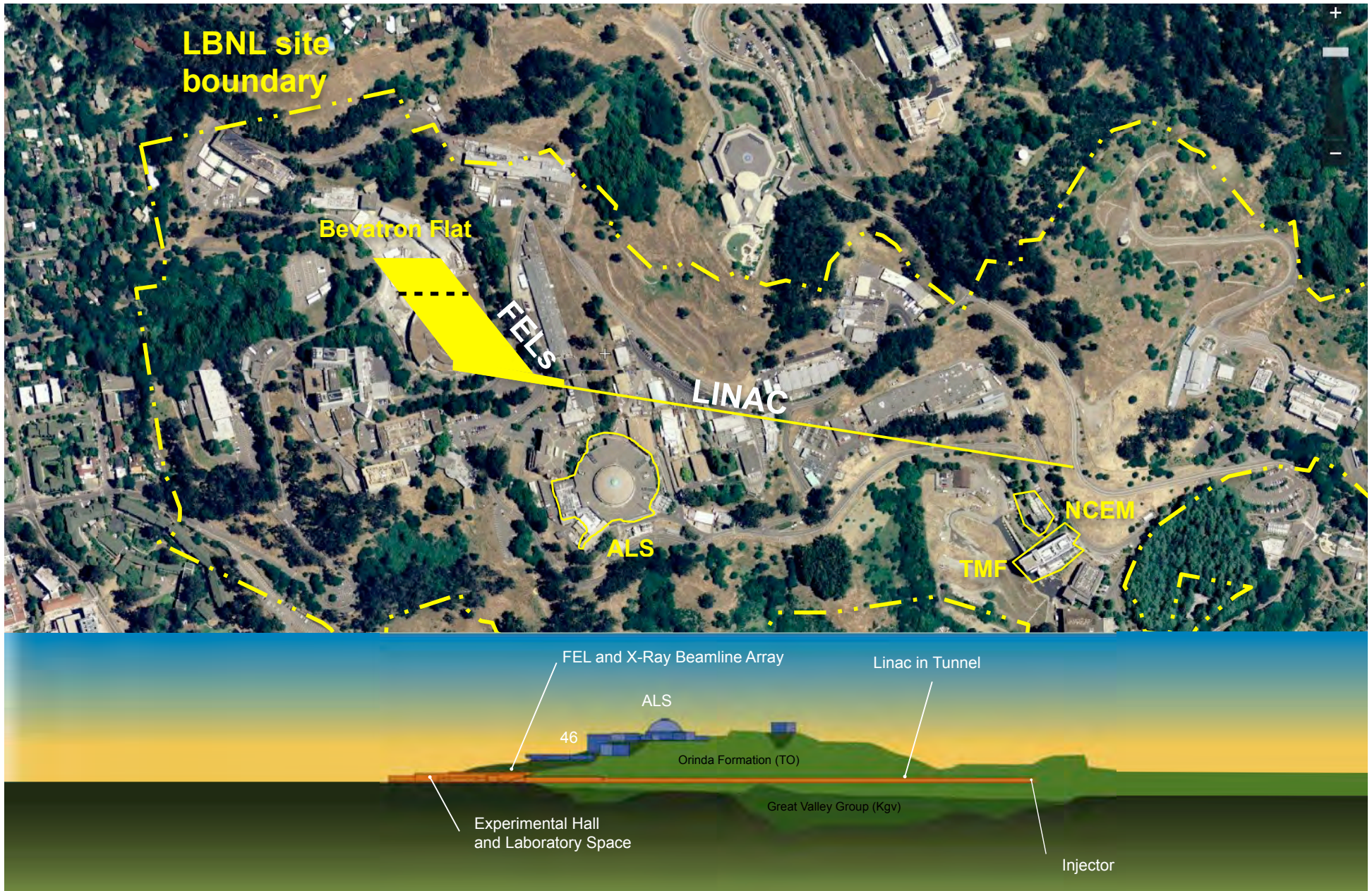
X-ray energy, flux, bandwidth, pulse length, ...

electron energy, gradient, undulator period, ...

cost/module, \$/Watt, \$/GSF, ...

NGLS@CDR

accelerator housing at LBNL (in tunnel - full buildout)



similar construction nearby





02/2010



02/2012

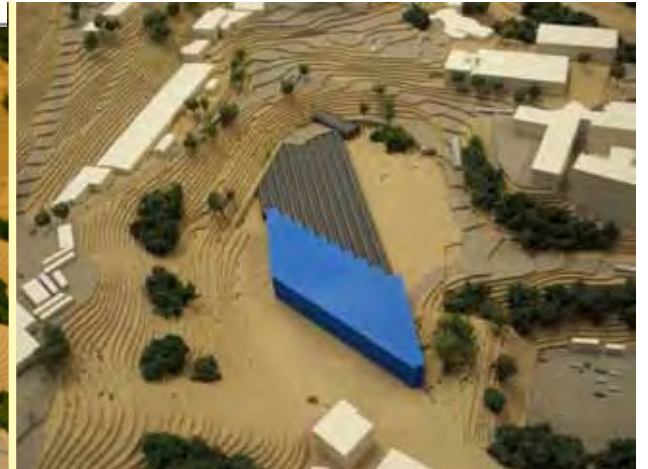


Soon

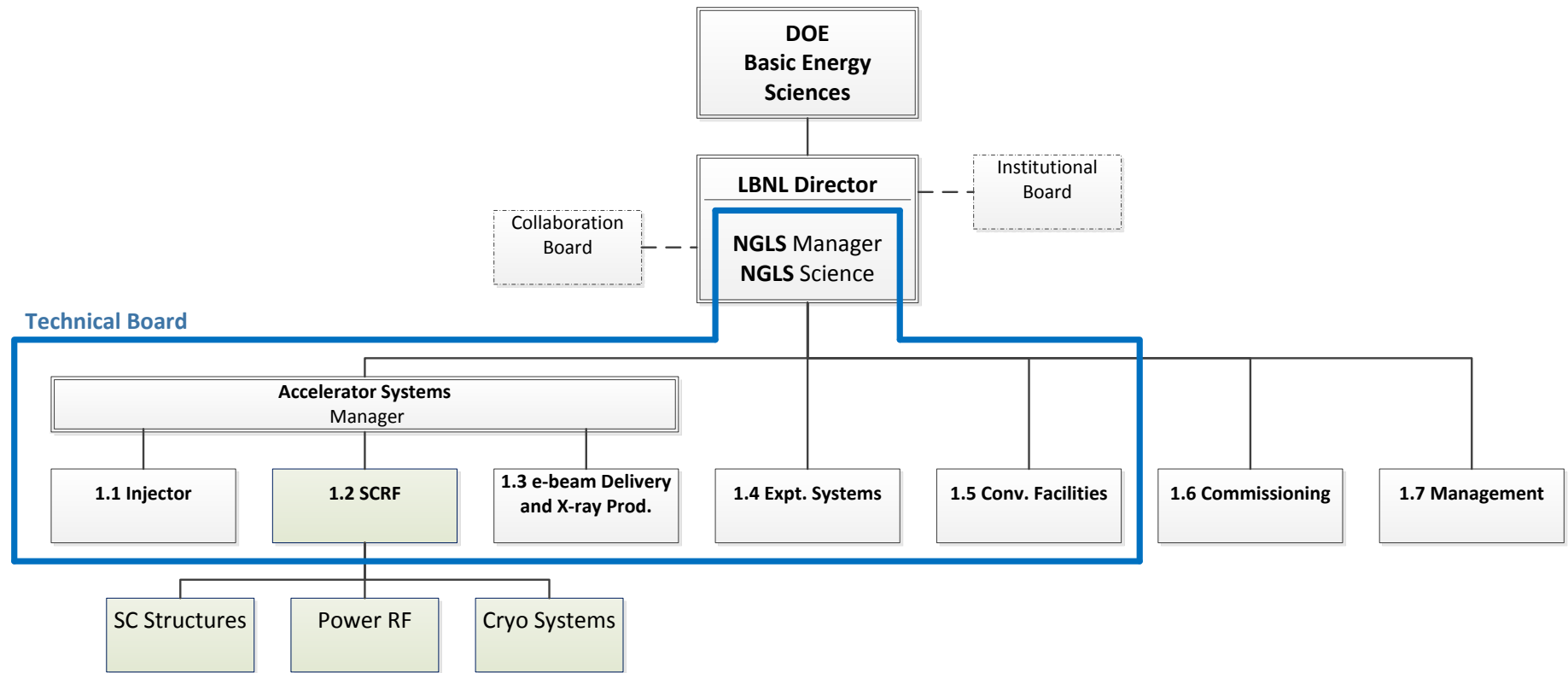


2020's

building construction at LBNL



organization



● FNAL coordinates and integrates SCRF

next steps

- Inclusion in FY14 Budget Request
- Buildings vs. Brightness (cost exercise)
 - Cost = $\frac{1}{2}$ Machine [$\propto E_{\text{BEAM}}$] + $\frac{1}{3}$ Conventional Facilities + $\frac{1}{6}$ Everything Else
- Preparation of CDR
- MOU being prepared
- Cost exercise: what are we proposing?